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Field-testing of SPRERI's open core gasifier for thermal application

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Abstract

One unit of Sardar Patel Renewable Energy Research Institute (SPRERI's) 1.25 GJ h^{-1} capacity open core down draft gasifier burner system, suitable for thermal application was installed at M/s Dinesh Pharmaceutical Pvt. Ltd., Nandesari, for steam generation. Producer gas burner was used in dual fuel mode (60% LDO (light diesel oil) + 40% producer gas). Gasifier consumed 78–80 kg h^{-1} of wood, and replaced 40% (20 l h^{-1}) LDO. The system was tested for a cumulative period of 600 h using sawmill woody waste as feedstock in test runs of 15–18 h. Financial analysis of the gasifier system showed that user could save about Rs. 221.8 per hour by using dual fuel (60% LDO + 40% producer gas) for steam generation. Economic analysis of the system tested in the field indicated the viability of the gasifier-based operation.

Keywords: Biomass; Open core down draft gasifier; Thermal application; Diesel displacement

1. Introduction

Heating systems based on wood, fuel oil, electricity and coal/lignite are common in small industries. Environmental pollution, poor process control and high cost are some of the limitations of these systems. On the other hand, biomass gasifier technology offers high thermal efficiency, good process controllability, economic viability and environmental acceptability while using agro and forestry residues available in rural areas and biomass based industries.

Sardar Patel Renewable Energy Research Institute (SPRERI) had developed an agricultural residue based open core down draft gasifier system of maximum woody waste conversion capacity of 100 kg h^{-1} suitable for various thermal applications. The system was operated for more than 600 h in the field and it gave satisfactorily consistent performance. For the field-testing and evaluation of the developed design the system was installed at M/s Dinesh Pharmaceutical Pvt. Ltd., Nandesari, for steam generation. This paper presents the results of evaluations of technical and economic performance of SPRERI gasifier system.

2. Material and methods

2.1. System description

The open core down draft gasifier system consists of a reactor shell, manual rotating type grate, ash pit, electric blower and dual fuel burner as major components. The reactor consists of a cylinder made in two parts. The bottom part of reactor is fabricated from stainless steel 310, 5 mm thick sheet and the upper part from mild steel, 5 mm thick sheet. The reactor volume is designed to require recharging once in an hour when working at the rated capacity of converting 100 kg h^{-1}. Photograph and schematic of the system are shown in Figs. 1 and 2 [1,2].

The reactor grate was made from cast iron. The grate area (0.62 m^2) is designed from specific gasification rate of 160 kg h^{-1} m^{-2} and the fuel input rate of 100 kg h^{-1}. Air distribution unit which supplements the air taken through the open top, consists of six number of air tuyeres of 20 mm in diameter. These side tuyeres are placed at 500 mm above the grate. The volume of ash pit (0.90 m^3) is sufficient to allow operation without ash removal for many hours [1,2].

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Fig. 1. Photograph of open core gasifier system for steam generation at Dinesh Pharmaceutical Pvt. Ltd., Nandesari.

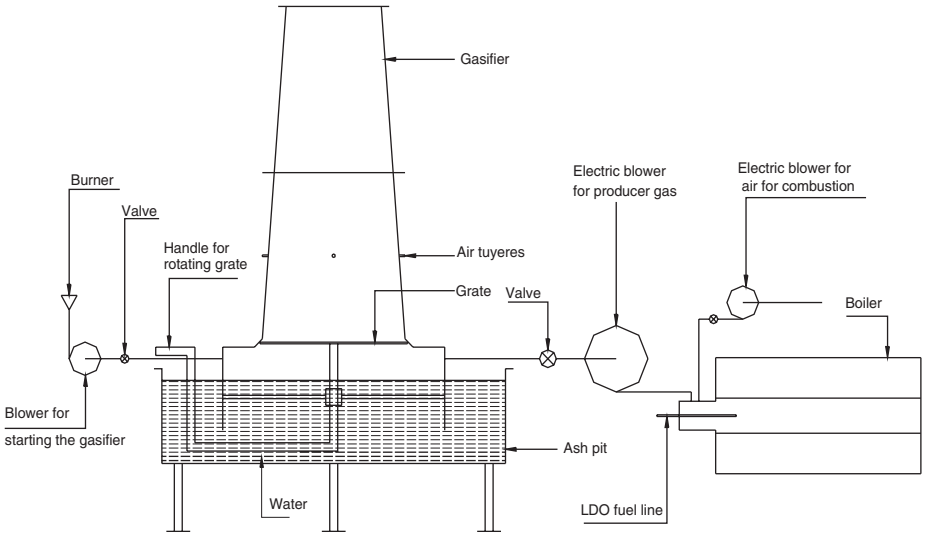

Fig. 2. Schematic diagram of open core gasifier system for steam generation at Dinesh Pharmaceutical Pvt. Ltd., Nandesari.

The producer gas was introduced to the boiler furnace zone through the centre annulus of a multiannular burner fabricated from mild steel. 40% of the energy input was the atomized LDO the rest was producer gas. In addition, to the air passing through the central tube secondary air to complete the combustion of the LDO and producer gas was passed through the outer annulus. The annular burner could also operate on LDO only.

2.2. Technical specifications of boiler

Type	:	three pass smoke tube wet back.
Capacity	:	900 kg h^{-1}.
Diameter of the fire shell	:	0.45 m.
Size of tubes	:	0.06 m.
Heating surface area	:	35 m^2.
Fuel used	:	LDO.
Current LDO consumption	:	50 l h^{-1}.
Working pressure required	:	8–10 kg cm^{-2}.
Steam temp. required	:	165–190 °C.

2.3. Technical specifications of gasifier

Type	:	down draft throat less.
Capacity	:	1.25 GJ h^{-1}.
Diameter of the gasifier	:	0.9 m.
Biomass consumption	:	100 kg h^{-1}.
Hopper capacity	:	300 kg.

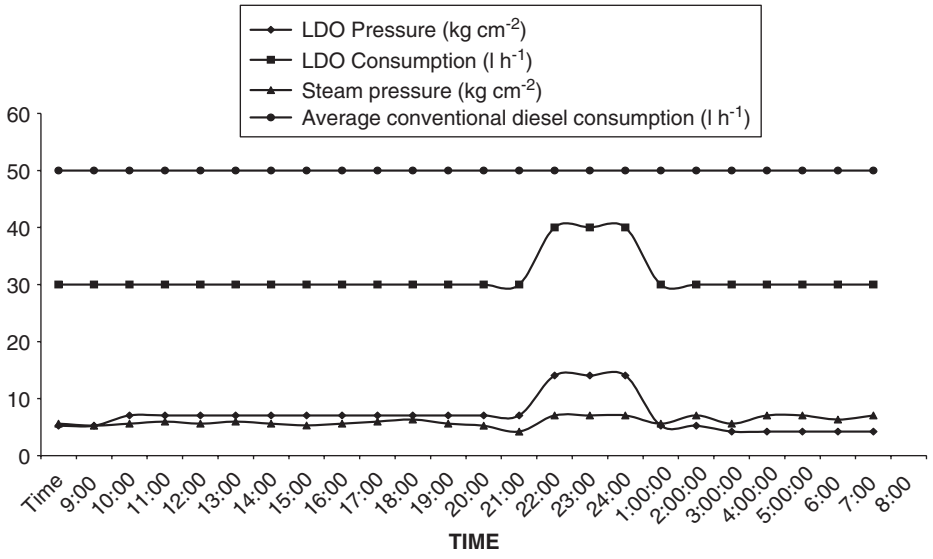

Fig. 3. Variation of steam pressure and LDO consumption rate with time at M/s Dinesh Pharmaceutical Pvt. Ltd., Nandesari.

Table 1
Comparison of fuel cost: net LDO and dual fuel mode operation

Fuel used	LDO consumption ($l\,h^{-1}$)	Biomass consumption ($kg\,h^{-1}$)	Total cost of fuel per hour (Rs.)	Saving (Rs. h^{-1})	Saving per day (15 h of operation per day) (Rs.)
LDO (100%) conventional	50	—	850	—	—
LDO (60%) + producer gas (40%)	30	78.8	628.2	221.8	3327

Cost of LDO = Rs. 17/l. Cost of wood = Rs. 1.5/kg.

Material of construction : stainless steel 310 for combustion and reduction.
: zone, the rest is mild steel.
Ash removal unit : manual-rotating type.

2.4. System operation

A 1 hp blower was used for starting the gasifier. A 5 hp air blower was used to supply air for dual fuel operation. The gasifier operation for startup and control was the same as described in our technical note [3].

The boiler was started up in LDO and the gas only introduced once the gasifier was in steady state.

3. Observations

To evaluate the system performance following parameters were constantly monitored:

1. Type and size of the feedstock.
2. Fuel consumption rate (FCR).
3. Steam pressure.
4. LDO consumption rate.

System was operated for a cumulative period of more than 600 h with individual test run of 15–18 h. Sun-dried woody sawmill waste with diagonal length 20–100 mm was used as feedstock [4,5]. Variation of steam pressure and LDO consumption rate is shown in Fig. 3, which reveals that the steam pressure remained in the range of 5.62–7.03 $kg\,cm^{-2}$ and LDO consumption around 30 $l\,h^{-1}$. It was consistent throughout the experiment except between time duration 21 h and 23 h when steam pressure reached 4.21 $kg\,cm^{-2}$, which was less than the lower limit of their requirement. That may be possible due to poor quality of producer gas. Hence, in order to increase steam pressure LDO consumption rate was increased from 30 to 40 $l\,h^{-1}$. Therefore LDO pressure was raised from 7.03 to 14.06 $kg\,cm^{-2}$. For the same output, earlier LDO consumption was 50 $l\,h^{-1}$.

4. Economic analysis

Procedure developed by SPRERI for economic evaluation of renewable energy technologies was adopted for the

analysis [6]. Dual fuel operation was compared with conventional LDO fired system. Per day saving in steam generation in dual fuel operation was Rs. 3327, as shown in Table 1.

5. Conclusions

1. Open core down draft gasifier performed satisfactorily in steam generation application. Performance data are shown in the Table 1, where the dual fuel operation was compared with conventional LDO fired operation. Gasifier consumed 78–80 kg of biomass to save 20 l of LDO.
2. Economic analysis of the gasifier system showed that user could save about Rs. 221.8 per hour by using dual fuel (60% LDO + 40% producer gas) for steam generation. Test results showed the economic viability of the gasifier-based operation. The pay back period for the gasifier system was only 1000 h of operation.

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